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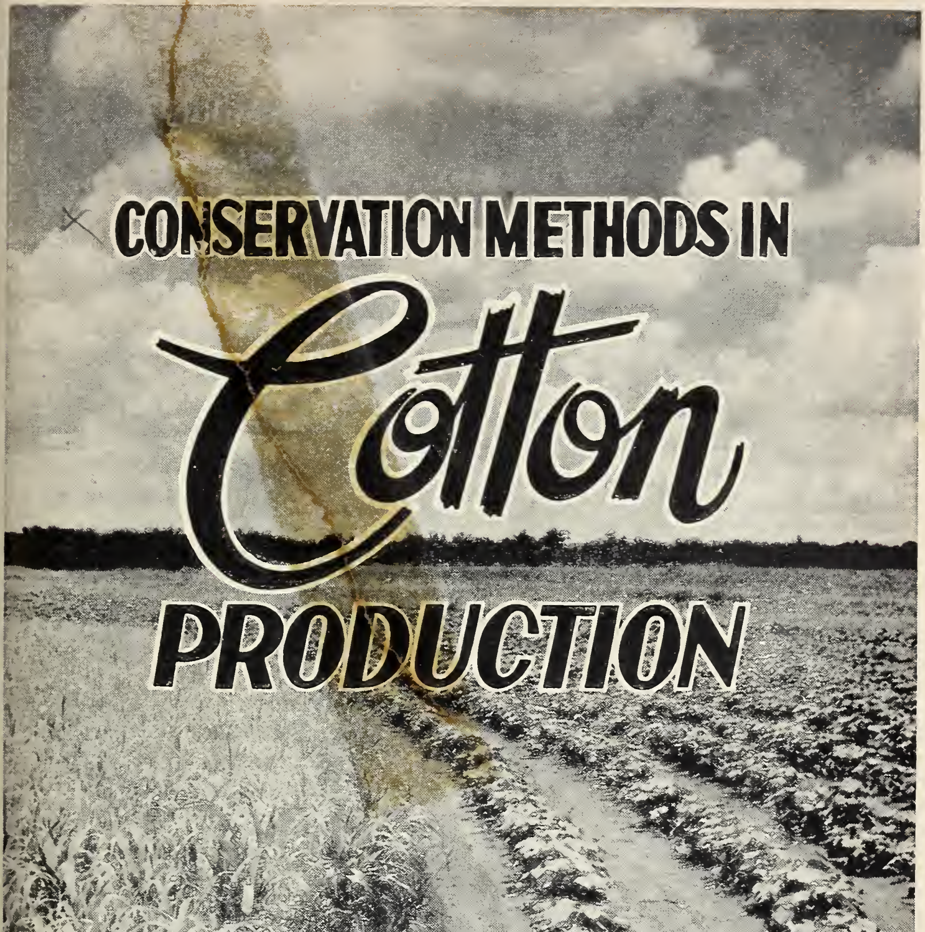

CONSERVATION METHODS IN Cotton PRODUCTION

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CONSERVATION METHODS IN COTTON PRODUCTION

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SUMMARY

Cotton, the principal cash crop of the Cotton Belt, is produced mostly on sloping cropland subject to erosion. Much of the cotton-producing area has been seriously damaged by past erosion. The most important and most difficult land problem of Cotton Belt farmers is the conservation of their cropland. It is a problem that requires the use of practical farming methods that reduce both soil and water losses while improving the productivity of erosion-damaged soil as well.

Erosion in the Cotton Belt is caused mainly by the frequent high-intensity rainstorms and the resulting wash of runoff waters on row-cropped farm land. Such storms are much more frequent in the Cotton Belt than in the eastern United States as a whole They occur most often during the main growing season; most of the erosion losses, therefore, come during the cotton-growing period of the year.

Cotton land is greatly exposed to the direct impact of raindrops (fig. 1). The soil-dispersing action of raindrop impact

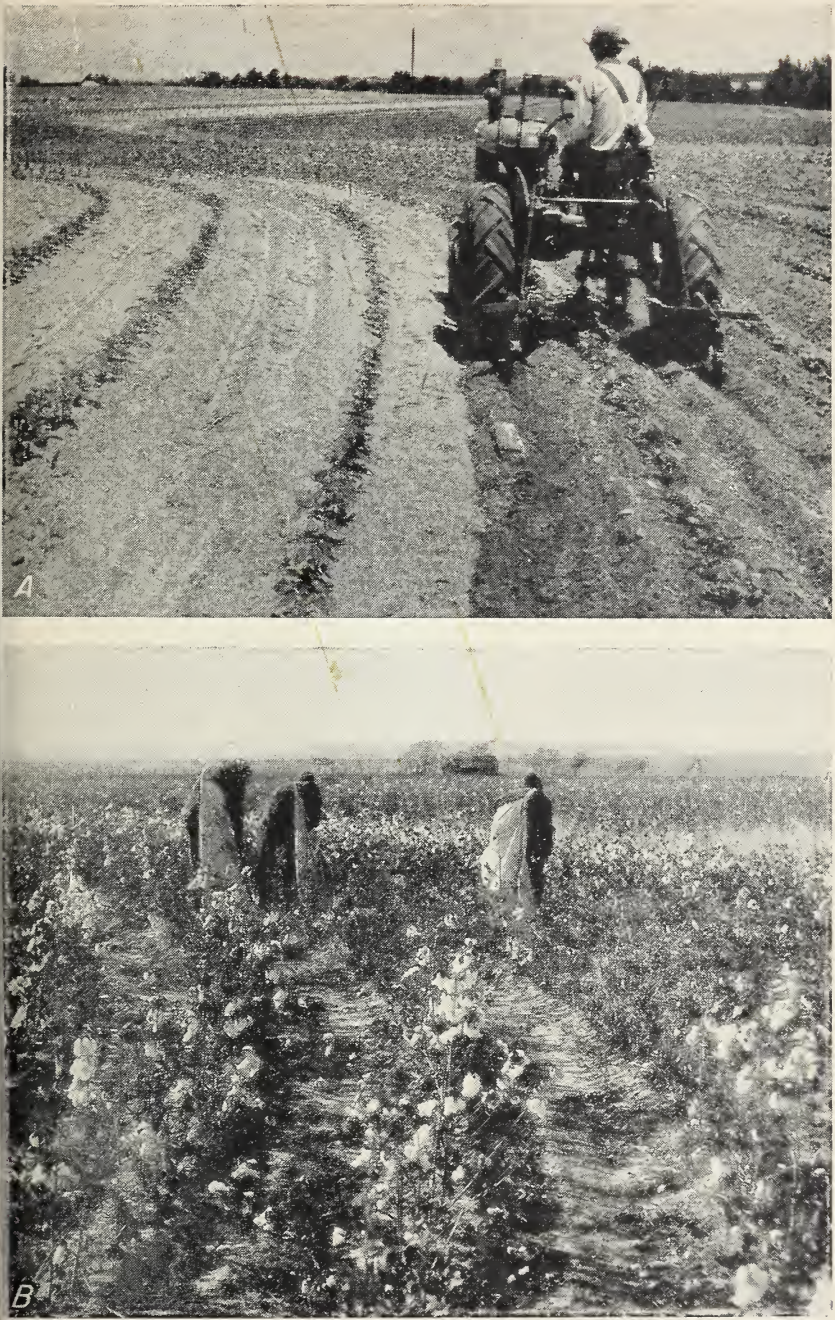

FIGURE 1.—Cotton land is greatly exposed to the hazards of erosion. It affords very little protection against the impact of raindrops either (A) in its early stages when it is intensively cultivated or (B) even when the ripe bolls are ready for picking.

causes puddling, pore-clogging, and sealing of the surface. Thus, infiltration of rain water into the soil is lessened and runoff and erosion are increased. The most effective way to prevent the damaging effect of rainfall is to keep the raindrops from striking the soil surface. This can be done with cover crops, residues, and mulches. In order to get the runoff water safely across sloping cropland, terraces are generally needed.

Exploitive cash-crop farming has been the too common Cotton Belt practice for years. The United States Department of Agriculture, in cooperation with State agricultural experiment stations, began its soil and water conservation research program in 1929. Up to that time, no effective attempt had been made to find cropping practices suitable for checking erosion in cotton culture.

There is a critical land situation in the Cotton Belt today because most of the soils are relatively poor, out of condition, and eroded. On the other hand, those not too badly eroded respond to good treatment. Much depends upon the use of science and skill in practical conservation farming. Profitable crop yields and effective protection and improvement of farm lands depend directly upon the way in which the terracing system, crop rotations, cover crops, pastures, and woodlands are established and maintained on the various classes of land of the farm.

On most farms there is a pressing need for reliable information as to practical methods of crop and soil management of the eroding croplands. The use of these methods can effectively reduce soil and water losses, improve and protect the soils, and pay off at the same time. This publication supplies such information.

Soil-loss measurements made over a period of years at several conservation experiment stations in the Cotton Belt indicate that sloping land continuously row-cropped is losing topsoil to plow depth at a rapid rate even though the land is well-terraced. So critical is the situation that within 30 to 60 years' time, subsoil farming is in prospect for the bulk of the row-cropped fields of the Cotton Belt located on average slopes, unless better conservation practices are adopted and maintained.

Close-growing summer cover crops greatly reduce soil and water losses. Legume cover crops and their residues are proving most effective (fig. 2). The hold-over effect of legume residues is also beneficial when the row crop follows. Such residues make the soil more absorptive, more resistant to erosion, and more productive.

Knowledge of these facts has made it possible to plan and use soil-conserving crop rotations that fit the soil and slope conditions on most Cotton Belt croplands. They permit cotton production on reduced acreage because they increase the acre yields. Such rotations also provide for diversified crop production, a practice that is highly desirable.

Recent experiments show that a variety of practical rotations greatly reduce soil and water losses and increase crop yields; and further, that the repeated use of good rotations of this type on the same land results in improvement in soil properties—

FIGURE 2.—Legume crops, like this lespedeza hay, are most effective in reducing soil and water losses.

organic-matter content and aggregation of the soil. For example, the 3-year rotation of small grain-lespedeza, volunteer lespedeza, and cotton has accomplished these results.

Conservation research in the Cotton Belt, to date, has supplied valuable information needed in farm planning. But the job is only begun. There are large areas in the Cotton Belt that are not adequately served by research of this type. The development of a permanent stabilized agriculture in the Cotton Belt depends in large measure upon the establishment and maintenance of conservation farming methods, before too much of the topsoils have been washed from potentially productive farm lands.

INTRODUCTION

The Cotton Belt has conservation problems that are peculiarly its own. The cotton economy has developed, over the years, as a result of several factors. Chief among them are the following: The cotton crop is perfectly suited to the climate of the Southern States. A small amount of farm equipment is required to produce it; there has been an abundance of cheap labor, and a ready cash market.

Cotton for cash, corn for feed, and fodder for mules, with a small acreage in oats followed by cowpeas for hay has been the typical cropping system. Too often repeated row cropping on erodible soils and slopes has produced the inevitable results—excessive erosion and soil deterioration.

Several obstacles peculiar to the Cotton Belt stand in the way of rapid progress in conservation-farming methods. There is a general lack of adequate farm buildings, of fencing, equipment, and farm machinery. Few cotton farmers are familiar with diversified farming methods. Few have developed the skills required for the production of other adapted crops or for the management of pastures and livestock. Processing and marketing facilities for a variety of farm products are, as yet, largely undeveloped.

In spite of these obstacles, progress is being made. There is every indication that the change-over from the soil-wasting practices of the past will proceed as rapidly in the Cotton Belt during the next decade, as in any part of the United States.

EXTENT OF EROSION

Cotton is grown mostly in nine Southern States: Oklahoma, Texas, Arkansas, Louisiana, Mississippi, Alabama, Georgia, and the Carolinas. These make up the Cotton Belt.

It is well known that the erosion problem is extremely critical in the Cotton Belt. The extent of the erosional damage to farm lands in typical problem areas was recently reported by Hugh H. Bennett (*1*),[1] chief of the Soil Conservation Service.

In the *Red Plains Country of Oklahoma* accelerated erosion has affected a wide area. In the *Texas Black Belt* 25 percent of the area has lost half of its topsoil; 15 percent has either lost all of it or has been so severely gullied that cultivation is practically out of the question. In the *Mississippi-Alabama Black Belt* and *Clay Hill Area* at least 80 percent of this area is subject to rapid decline wherever cultivated without the application of an effective erosion-control program. In the extensive *Interior Coastal Plain Areas* of the Southern States from 50 to 75 percent has suffered seriously from erosion, due principally to too frequent use of clean-tilled crops. In the *Piedmont of the Southeast* approximately 77 percent of the cultivated area is used for row crops that give little or no protection from erosion. As a result, the area of severely eroded land is extensive. Erosion control is the most important and most difficult land problem confronting Piedmont farmers. Already, the process has violently upset the economic and social life of many communities, literally crowding people off the land.

Both sheet and gully erosion are active on sloping cropland fields. The gullying type is the more spectacular. It roughens the field surfaces, making the use of modern farm machinery difficult or impossible. The loss of topsoil by sheet erosion is probably more serious. It drains the land of its fertility, and ultimately leads to subsoil farming which is rarely profitable in the Cotton Belt.

PRIMARY CAUSE OF EROSION

Erosion in the Cotton Belt is caused primarily by rainfall from storms, and the resulting erosive wash of the runoff waters on sloping row-cropped farm lands. In western areas, alternating wind erosion and water erosion have caused serious damage to the cultivated croplands. In the West, drought during the growing season often limits the successful growing of summer annual types of cover crops.

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[1] Italic numbers in parentheses refer to literature cited, p. 32.

Climatic hazards make the erosion problem especially difficult in the Cotton Belt. Over these climatic hazards the cotton farmer has no control except by the use of soil-conserving practices. The only type of agriculture likely to endure in the erodible sections of the Cotton Belt must be so planned, established, and maintained as to offset the land-damaging effects of these climatic factors.

Frequency of Excessive Storms

The average annual rainfall across the Cotton Belt, west to east, varies from 18 inches to 50 inches. But rainfall in the growing season (April-September, inclusive) varies only from approximately 18 inches to 27 inches.

The heaviest monthly rainfall of the year, on the average, occurs sometime during the cotton-growing season. In the West, in Texas and Oklahoma, it comes in May. In the Middle States it comes in early spring and again in midsummer. Toward the eastern end of the Cotton Belt the heaviest monthly rainfall is expected in August.

These heavier monthly volumes of rainfall are closely associated with intense rates of rainfall. Such rains of considerable volume are termed "excessive rainstorms."[2] From four to six of these excessive storms are expected each year, on the average, in all of the Cotton Belt States. A study of the frequency of these storms made by the United States Department of Agriculture is available in published form (*9*). A brief summary of these findings as to the frequency of intense rains in the principal areas of the Cotton Belt is given in the following paragraphs.

Excessive storms vary in intensity. The most intense storms occur more often in East Texas and Oklahoma, and in a belt bordering the Atlantic and Gulf Coastline. They are somewhat less intense, and not quite as frequent, along the northern border of the Cotton Belt. This trend continues northward across the eastern half of the United States. One or two of these very intense storms often cause most of the total year's erosion losses.

In early spring, from a focal area along the Gulf Coast an average of one excessive storm during March is expected, according to 30-year Weather Bureau records as interpreted by Yarnell. Nearby areas in the central part of the Cotton Belt are affected. They have about half that rate of expectancy in March.

In April, another focal area of high frequency normally develops in Central Texas, with storms occurring in excess of one severely erosive storm in April. Meanwhile the central portion of the Cotton Belt also approaches the same rate in April.

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[2] Under the term "excessive rainstorms" are included those with maximum intensities of at least 3 inches per hour for 5 minutes, 1.8 inches per hour for 10 minutes; 1.4 inches per hour for 15 minutes, etc., to 0.8 inches per hour for an hour.

In May, a high frequency of excessive storms, approaching two in number, extends through Central Texas and Oklahoma, but toward the east across the Cotton Belt the average frequency declines generally to less than one storm in May.

Beginning with June, the pattern changes. By then the Texas-Oklahoma high frequency has almost completely moved northward out of the Cotton Belt into the Central Plains States.

During June, in the Cotton Belt, the high-frequency storm areas move to the east. During this month, an average of about one excessive rain is expected from Alabama eastward through Georgia and the Carolinas, with generally lesser rates to the west.

In July, another belt of maximum frequency of nearly two storms per month occurs as a narrow band in the southeast, crossing the lower Coastal Plain sections of Mississippi, Alabama, and Georgia while the eastern half of the Cotton Belt in July is subject to an average of 1 to 1½ storms.

To the westward, the frequency remains low. The July pattern continues through August. Then, from September through February the frequency of excessive storms diminishes rapidly through fall and winter in the entire Cotton Belt.

The frequent occurrence of these highly erosive rainstorms during the growing season of the year is the principal cause of erosion. Sloping cultivated soils, the world over, can be expected to suffer moderate to severe erosional damage under similar climatic hazards.

THE EROSION PROCESS

Advance knowledge of the probable periods and amounts of excessive rainfall is helpful in timing protective measures. But knowledge of the details of the erosion process is essential in the planning and application of such measures.

In the Cotton Belt, with its long warm growing season, mild winters, and generally ample rainfall, runoff water from rainfall is the greatest destructive force with which we must cope. Runoff results when the rate of rainfall exceeds the rate of infiltration of water into the soil. This in turn depends to a large extent on whether the soil is exposed to the direct impact of raindrops.

Two kinds of soil movement are involved in the water-erosion process. These are raindrop splash and surface flow. The impact of raindrops breaks down soil clods and aggregates, and tends to develop a single-grain structure. It makes the surface water muddy. This causes puddling and compacting. The mud in the water seals the pores of the soil and impedes infiltration. This effect of raindrops can only be prevented by keeping them from striking the soil surface. Cover crops, residues, and mulches break the impact of raindrops and give the most effective protection.

Since nearly all land surfaces are sloping, raindrops splash soil particles into surface flow. Control of surface flow presents another problem. In order that the water shall flow off the fields with the least possible damage to the soils, terraces, diversion ditches, and other mechanical measures are required.

In cotton production, the surface soil is not as well-covered with a canopy of vegetation as in regions with close-growing cover crops. Soil-laden runoff water soon concentrates, during heavy storms, to form large washes and gullies. As its velocity increases the water cuts deeper into the soil or subsoil, carrying away large quantities of soil material of assorted textures. Along with the coarser soil particles and aggregates it carries a high content of the principal soil fertility components—the silt, clay, colloid, organic matter, and fertilizers. Analyses of the washoff have shown that it is much richer in nitrogen, phosphoric acid, and potash than the soil from which it came. The soil organic matter, being lighter than water, floats off readily.

With repeated row cropping to cotton the situation is aggravated because the soil generally contains but little organic matter. This makes it less absorptive of rainfall. Such soil has a lowered degree of aggregation. The granules of soil break down readily under rainfall impact. A tight surface "skin" forms quickly, decreasing infiltration and increasing the runoff. On drying, this "skin" produces a crust which adds to the farmer's difficulties in securing a good stand and growth of crops.

EROSION-CONTROL MEASURES

Length and degree of slope affect the velocity of flowing water and consequently the rate of erosion. Row-crop culture

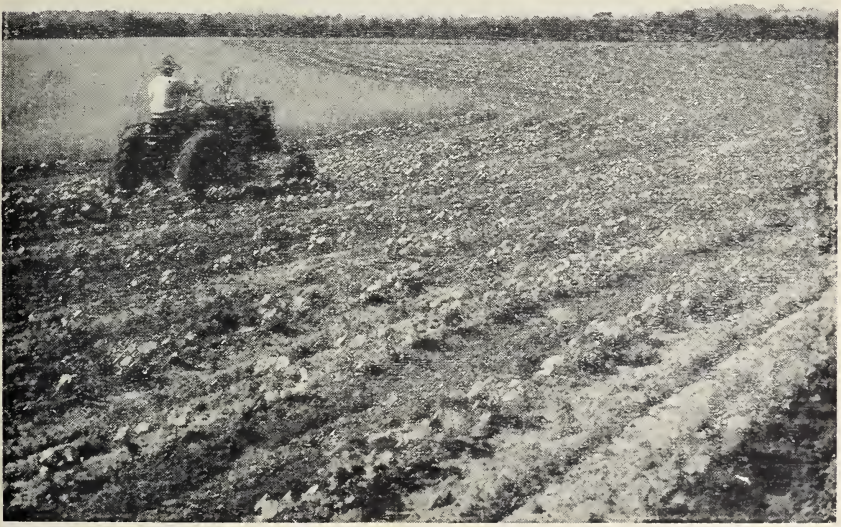

FIGURE 3.—This cotton land is contour-plowed, terraced, and in a strip-crop rotation, a combination of measures, which when properly adapted to an area, will protect it against the constant heavy losses of soil and water in any part of the Cotton Belt.

results in greater soil loss with increasing degree of slope. The longer the slope, the greater is the erosion hazard.

Terraces are effective in reducing the slope lengths; they intercept runoff water at safe intervals and drain it slowly off the fields to suitable protected outlets. The effectiveness of good terraces in a well-planned water-disposal system is clearly shown by the results of experiments at all the conservation experiment stations in the Cotton Belt.

In fact, adoption of the well-established practices and methods of control, that come under the term "conservation farming," is the first step that must be taken to protect cotton lands against the constant heavy losses of soil and water, in any part of the Cotton Belt. These practices include contour plowing, terracing, rotation of crops, strip cropping, cover crops, plant residue mulch, grassed waterways for terrace outlets, and diversion ditches where needed (fig. 3). They will be more fully described in subsequent pages, particularly with regard to their use and value in the several regions of the Cotton Belt.

On land that is adequately terraced, planted to good rotations, strip cropped, and provided with well-grassed waterways, the principal remaining erosion-control measure is adequate soil and crop management. This final measure—soil and crop management—is the one over which farmers have the greatest control.

Soil and Crop Management

It is becoming increasingly clear that conservation methods need to accomplish much more than merely reduce soil and water losses. The critical farm-land situation in most of the Cotton Belt requires that erosion-damaged farm lands be rebuilt to productive levels. At the same time they must be protected by good erosion-control methods. The conservation methods, just mentioned, supply the foundation upon which to build and maintain an enduring agriculture by soil and crop management.

Heretofore, exploitive cash-crop farming has been the general practice. Protective and soil-improving systems of practical farming that are profitable are urgently needed.

Most of the Cotton Belt soils are relatively poor, out of condition, but responsive to treatment. They need to be improved in mineral-nutrient content. They need systematic additions of organic matter to make the soil more absorptive and to bring about better soil tilth and mellowness. All sloping croplands must be adequately protected against erosion if the level of productivity in the Cotton Belt is to be raised and profitable crop yields maintained.

There is no complete answer as yet to these urgent needs, but progress has been made after almost two decades of research at several conservation experiment stations in the Cotton Belt. Much credit is also due other State and Federal agricultural agencies that have helped effectively to establish soil-improving and conservation practices on cotton lands during the past 10 or 15 years.

RESEARCH IN SOIL CONSERVATION

This publication gives a brief review of the most significant results of experiments at the conservation experiment stations in the Cotton Belt, where soil- and crop-management methods have been under study for a number of years. Research scientists at these stations have specialized in finding and testing cropping practices suitable for eroded and erodible soils. These stations were established at Guthrie, Okla.; Temple and Tyler, Tex.; Statesville, N. C.; Clemson, S. C.; and Watkinsville, Ga.

In addition to developing effective mechanical and vegetative methods of control, all of the research work on stations in the Cotton Belt over the last 18 years has shown conclusively that forest, grass, or close-growing crop covers are outstanding for erosion-control purposes. No other practical substitute for cover crops has been found.

Historically, the row-crop type of farming has dominated most of the Cotton Belt areas. The South, however, is by no means the only section of the United States where the cash-crop type of farming has resulted in excessive rates of erosion. But in the Cotton Belt little progress has been made until recently with crop rotations, chiefly because of the belief that fairly good yields of cotton can be made repeatedly on the same land.

Cotton is said to be "easy on the land." With the use of improved cotton varieties and better fertilization, cotton yields have in many cases been temporarily maintained or increased on fairly good land, in spite of continuing erosional damage. Eventually, however, the topsoil becomes thinner and more eroded and cotton yields decline. All of the experimental results show that it has been impossible to produce paying crops of cotton continually on severely eroded cropland.

As a result of this practice, widespread abandonment of eroded fields and farms is common, particularly in the hillier sections. It is now recognized that row cropping to cotton or any other row crop year after year cannot be continued indefinitely on sloping land in the Cotton Belt.

The following sections describe the conservation methods that have reduced erosion and increased yields at six stations in the Cotton Belt representing different areas with a variety of soils and climate. Following a brief description of typical research findings from these stations in both western and eastern areas, results and conclusions of specialized studies of the culture and conservation of cotton land will be summarized from the findings of the Watkinsville, Ga., conservation station.

CONSERVATION RESEARCH ON THE RED PLAINS OF OKLAHOMA

In Oklahoma, at the Guthrie station (*3*), on a slope of 7 percent, contour culture reduced erosion on large plots, 80 feet wide and 181.5 feet long. The soil is known as the Stephensville fine sandy loam. During the 1932-38 7-year period, plots on which cotton was grown each year followed by wheat as the winter cover crop, and on which both the row-crop rows and drill rows of the small grain crop ran up-and-down slope, lost an average of 9.1-percent runoff and 38.2 tons of soil per acre per year. Plots with the same crops, planted across the slope on the contour, lost 8 percent of the runoff and 16.6 tons of soil per acre during the same period. Contour culture proved to be worthwhile with cotton.

The Guthrie station reported favorable results with a specially designed conservation-type crop rotation. Runoff and soil losses were sharply reduced, and crop yields were increased.

In the fall of 1929 and spring of 1930, three runoff plots at the Guthrie station, on a 7.7-percent slope 72.6 feet long, were planted to one of three of the crops represented in the following 3-year rotation: Wheat-biennial sweetclover, second-year sweetclover, and cotton. Cotton was grown continuously on the check plot during the 17-year period, 1930-46 (*4*). Meanwhile the crops grown in the rotation followed in proper sequence on each of the three rotation plots. For the 17-year period, the continuous cotton check plot lost 11.8-percent runoff and 15.4 tons of soil per acre annually; the rotation plots averaged 7.9-percent annual runoff and 3.6 tons per acre soil loss (fig. 4).

The reduction of soil loss averaged 76.3 percent during the 17-year period, as compared to the average loss of soil from

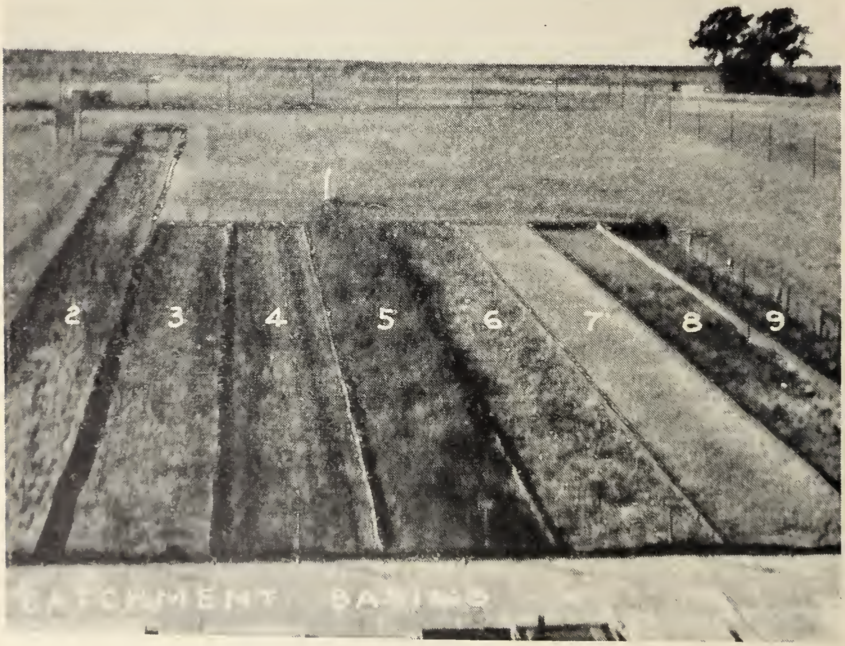

FIGURE 4.—View of the control plots at the Guthrie, Okla., station.

the plots in continuous cotton. The average reduction of water loss was 32.8 percent.

These are substantial reductions in soil and water losses averaged over the 17-year period and covering five and two-thirds rotation cycles on the same erodible land. But they tell only part of the story. They do not show the progressive gains, year after year.

Reductions in water losses, which resulted from the use of this rotation during the first 5 years (1930-34), averaged 19.9 percent. During the third 5 years (1940–44) they averaged 47.6 percent, and during the 2 final years (1945–46) they averaged 56.2 percent. These figures emphasize the fact that the soil on the rotation plots had become progressively more absorptive than the soil on the continuous cotton check plots.

Reductions in soil loss due to repeated use of this rotation ranged between 70 and 80 percent over the entire 17-year period, averaging better than 75 percent. Thus the rotation resulted in a consistent saving of three-fourths of the amount of soil that was being lost from plots in continuous cotton from the same rains on the same field.

The yield of seed cotton on the check plot in continuous cotton during the last 5 years of the 17-year period was 96 pounds per acre less than it was during the first 5 years. But on the rotation plots it was 170 pounds more.

It was learned, also, that a good conservation-type rotation often does a relatively better job of soil and water loss reduction, when the storms are severe. That is, the rotation may reduce the soil loss during severe storms proportionately more than during milder storms. This happened at Guthrie in 1932. The continuous cotton check plot lost a maximum of 68.6 tons per acre of soil that year. The average amount of soil lost in the rotation plots in 1932 was 13.6 tons per acre, or only 20 percent as much. In other words, the rotation prevented four-fifths of the extremely high soil loss, in a severely erosive year, whereas, in the average year three-fourths of the soil loss was checked by the rotation.

This rotation, adapted for typical sloping-land conditions in Oklahoma, compares favorably with a similar 3-year rotation based on annual lespedeza, which has wide application in the more humid sections of the Cotton Belt.

The Guthrie station also recorded the losses from a desurfaced plot in continuous cotton. Normal surfaced plots of continuous cotton on the Stephensville fine sandy loam soil at the Guthrie station during the 11-year period 1930-40 showed an average runoff of 13.5 percent less and an average erosion of 11.1 tons less per acre than the desurfaced plot. The average rate of soil loss for the normal-surfaced plot was 16.5 tons per acre per year. Clearly, this plot will lose its soil at a still faster rate as the depth of its topsoil becomes less and less. In other words, as erosion advances in Oklahoma, its rate can be expected to increase.

In experiments with strip cropping on unterraced land, 12-

row strips of cotton and about equally wide strips of alfalfa were alternated on the contour. Also, similar cotton strips were alternated with strips of oats followed by Sudan grass. On a slope of 4 to 4½ percent, and a 340-foot slope length, the strip-crop pattern with the alfalfa was fairly effective in checking both soil and water losses. The nonlegume, close-growing crops of oats and Sudan grass did not check erosion so well. Both of these crops allowed considerable runoff.

CONSERVATION RESEARCH ON THE BLACKLANDS OF TEXAS

The Temple, Tex., conservation experiment station (*6*) is located in the "black waxy belt" on Austin clay and Houston black clay. These soils are highly erodible. Here, control of erosion proved difficult from the beginning. Contour culture of cotton on 4- to 6-percent slopes did not check erosion so well as did running rows up-and-down the slope. In fact, contour cultivation on a large experimental plot resulted in gullies at the beginning of the experiment. During the period of the test, 1933-37, gullies widened and deepened. On these exceptionally erodible Blackland soils it became apparent that contour cultivation without the protection of terraces and grassed waterways might become more harmful than helpful. Wherever washes and small gullies occurred in cropland fields it was found that in plots without terraces at regular intervals, runoff too often concentrated in the low places, broke over the contoured beds, and cut larger gullies in the soil. Even with terraces it was found that contour cultivation, to be effective, must drain into protected waterways unless the terrace interval is smooth and unbroken by depressions.

On plots with 4-percent slope that were 72.6 feet long, the soil and water losses from continuous corn were compared with losses from a 3-year rotation of oats, cotton and corn. All rows ran in a down-slope direction. Data for an 11-year period, 1931-41, showed that the continuous corn plot lost 13.6-percent in runoff and 20.6 tons of soil per acre per year. The rotation plots averaged 9.6-percent runoff and 13.0 tons per acre of soil loss. The protection thus secured was almost entirely due to the oat crop. This rotation contained no legume, and only minor protective value was obtained from the oat-crop residues. Vetch, used as a winter cover crop for spring green manure, failed to reduce soil and water losses materially in other row-crop rotations.

In this "black waxy belt" of Texas, a serious soil-borne disease known as root rot prevents the use of many summer-legume crops that might otherwise supply a "summer-legume base" on which to build better conservation-type rotations. To date, Hubam clover appears to be the most promising legume for this purpose. Erosion rates are extremely severe in this area, even though the prevailing slopes are less steep on the average than in most of the Cotton Belt. Extensive tests with promising grasses are under way at this station.

Strip cropping with alternate strips of cotton and oats on unterraced land gave fairly effective control on gentle smooth slopes. On steeper slopes the oats were not effective.

CONSERVATION RESEARCH ON THE SANDY CLAY LANDS OF TEXAS, ARKANSAS, AND LOUISIANA

The Tyler, Tex., conservation experiment station studies (*8*) were made in East Texas on the eroded sandy clay lands of the West Gulf Interior Coastal Plain Area. At this station it was found that the severe erosive storms occurring most frequently in May, June, or July were the major erosion hazard, and that effective conservation methods must be designed to meet this situation.

Continuous cotton in contoured rows allowed an average of 19.9-percent runoff and 24.1 tons per acre soil loss per year over the 10-year period, 1931-40. These losses occurred on slopes of 8¾ percent, 72.6 feet long, of the Kirvin fine sandy loam soil. Two different 3-year rotations were used successively on the same plots during the period. Plots in a rotation of lespedeza, cotton, and corn, with a small-grain crop grown each winter for spring green manure during the 1931-35 period lost an average of 17.2 tons per acre of soil. This compares with the loss of 24.1 tons per acre from the continuous cotton plot for the same period.

During the following 5-year period, 1936–40, the rotation was changed to cowpeas, cotton, and grain sorghum, with a vetch cover crop each winter for spring green manure. The soil loss from this rotation averaged 16.2 tons per acre whereas the continuous cotton plot lost an average of 25.7 tons per acre during the same period.

The rotations under test at Temple and at Tyler were not very protective. They lacked the amount of cover during erosive periods of the year that was provided by 2 years of sweetclover in the 3-year rotation tested at the Guthrie station. Also, two row-crop years out of three were obviously too many, on erodible land. We now term such rotations as "out of balance." Most croplands of moderate slope in the Cotton Belt require rotations providing at least 2 years' growth of close-growing, legume summer cover crops preferably, for every row-crop year, in order to protect and improve these eroded soils.

A strip-cropping experiment on unterraced land was reported by the Tyler station. On plots of Bowie fine sandy loam with a 5.5-percent slope 145 feet long, strips of cotton followed by vetch for green manure annually were alternated with strips of sorghums and cowpeas, followed by oats. The strip-crop pattern reduced the soil loss by two-thirds, by comparison with the cotton-vetch succession used as the check method, but did not reduce the water loss.

Strip cropping without the use of terraces to divert surplus runoff water at intervals on erodible slopes has not generally been very successful in the Cotton Belt, for the reason that occasional runoff concentrations produce field gullies. This has been especially true on the longer slopes.

CONSERVATION RESEARCH ON THE SANDY CLAY LANDS OF THE CENTRAL PIEDMONT

The conservation experiment station at Statesville, N. C., (*2*), near the eastern end of the Cotton Belt was located on Cecil sandy clay loam soil. At this station, on plots of 10-percent slope 72.6 feet long, for the 10-year period, 1931–40, plots of continuous cotton showed average losses of 12.4 percent runoff and 31.2 tons per acre of soil per year. Most of these losses occurred during the 3 summer months, June, July, and August, in which 57 percent of the water loss and 72 percent of the annual soil loss took place.

A 4-year rotation was tested for two complete cycles on the same land, during the 8-year period, 1931-38. This rotation consisted of wheat-lespedeza, volunteer lespedeza, cotton, and corn. The average annual losses for the rotation were 10.0 percent runoff and 14.4 tons per acre of soil. Records for each crop year show that runoff was highest during the wheat-lespedeza year, and lowest during the volunteer lespedeza year. But very little soil was lost during either of these years, particularly the latter. Cotton following the lespedeza lost two-thirds as much soil as continuous cotton, but during the corn year erosion loss was nearly as high as with continuous cotton. The protective hold-over effect from lespedeza was dissipated during the cotton year in the rotation.

The indicated protective effect of the lespedeza residues during the cotton year in this rotation prompted the Statesville station to put in a special test, using applied compost and manure. Very striking results were obtained on continuous cotton land of 10-percent slope 72.6 feet long, during the 1938–40 period. Spading under heavy annual applications of 12 tons of compost, and 8 tons of manure per acre on separate plots reduced runoff during the cotton years by more than half, and erosion to as little as one-fifth the amount lost by continuous cotton. Yields of cotton were low where grown continuously without treatments, but very high following the compost and the manure treatments. Expressed as erosion-production ratios, land continuously in cotton without treatment lost 393 pounds of soil for each pound of lint cotton produced. With compost the corresponding figure was 32 pounds; and with manure only 15 pounds of soil were lost per pound of lint cotton produced.

APPLICATION OF CONSERVATION RESEARCH IN THE SOUTHERN PIEDMONT

The Southern Piedmont Conservation Experiment Station at Watkinsville, Ga., is one of the newer projects. The experimental work on this station was designed mainly to develop a variety of practical soil- and crop-management methods for conserving soil and water and insuring high crop production. A tenant-operated 100-acre conservation farm, located on the station, serves as a practical demonstration of successful conservation farming methods.

The station's experimental set-up includes a large number of soil- and crop-management methods. These are tested on three principal classes of upland on the Cecil soils. Croplands of gentle, moderate, and steep slopes, with their typical degrees of past erosion, are included in these studies.

Several land capability classes will be referred to throughout this publication. The Soil Conservation Service, in its land-classification system devised for simplifying the approach to conservation land management, recognizes 8 classes of land. The first 4 classes, designated I, II, III, and IV are the ones principally involved in the soil- and water-conservation problem on croplands in the Cotton Belt. The other land classes include wet lands, rocky slopes, and nonagricultural types.

Most cotton farms in the Piedmont, for example, contain very little acreage of level uneroded cropland of class I. There is some gently sloping slightly eroded class II, but the majority of the cropland acreage falls in class III, which is moderately sloping and considerably eroded land. There is almost always some steeply sloping, badly eroded class IV land on the average farm.

A series of 43 runoff plots measure rainfall, runoff, and erosion on these 3 land classes. Plots are laid out to represent terrace-interval conditions. All row crops are grown on the contour. Selected cropping practices are placed on the runoff plots. Work plans include a large series of supplemental field-plot tests of a comprehensive series totaling 27 specific cropping practices. Equalized fertilization is used throughout, so that experimental results will indicate the adjustment of each practice to the principal classes of cropland. A review of principal results is published annually[3].

The utilization of crop residues has been featured in many of this station's soil- and crop-management studies. Cotton and corn stalks always remain on the land. Straw, following combine-harvest, is left on the land. Lespedeza seed-harvest residues remain on the land to supply valuable protection against erosion, and soil-building effects when stubble mulch is turned under. In various experiments the residues of kudzu, sericea, winter legumes and grasses, soybeans, grain sorghums, and other crops are being studied to determine their best conservation use.

The 43 runoff plots were located on land representing typical field conditions on 3-, 7-, and 11-percent slopes representing land capability classes II, III, and IV. Plot lengths, approximating terrace spacings in common use, are 105, 70, and 35 feet long, respectively. Soil samples are collected regularly from the runoff plots and from the extensive system of supplemental plots to afford opportunity to trace changes in nutrient content of the soil, nitrogen and organic-matter gains or losses, and changes in mellowness or degree of aggregation of the soil. A complete set of yield records also serve to measure productivity.

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[3] Hendrickson, B. H., Carreker, J. R., and Adams, W. E., REVIEW OF PRINCIPAL RESULTS, 1941, 1942, 1943, 1944, 1945, and 1946. U. S. Soil Conserv. Serv., South. Piedmont Conserv. Expt. Sta., Watkinsville, Ga. (Mimeographed.)

Table 1 lists average acre yields for the 5-year period 1944-48, for principal crops grown on three land classes, in the triplicate plot system. The figures in this table clearly indicate two very important points: (1) As slopes steepened and the degree of past erosion increased, all of the yields declined; and (2) peanuts and cotton produced good yield increases when grown in rotations.

TABLE 1.—*Effect of rotations on crop yields for the 5-year period, 1944-48*

Type of rotation		Crop yields per acre on land in —		
		Class II	Class III	Class IV
Continuous peanuts	pounds	937	------	------
Continuous peanuts with vetch annually for green manure	do	1,049	------	------
Peanuts in a 2-year rotation	do	1,706	------	------
Continuous cotton, seed cotton	do	984	894	404
Cotton in rotation, seed cotton	do	1,239	1,014	772
Corn in rotation	bushels	43	35	25
Oats in rotation	do	68	59	44
Vetch in rotation, for green manure	tons	7.8	6.9	6.1
Annual lespedeza hay in rotation	do	1.9	1.6	------

It is important that we know the rate of soil decline, as well as the practical methods for rebuilding the productivity of the land. Some examples of both will be given.

During the recent 9-year period, 1940-48, runoff and soil loss were measured on Cecil sandy loam in continuous cotton in contour culture on class III land. On plots with 7-percent slope, 70 feet long the runoff averaged 22.5 percent and soil loss 24.5 tons per acre. The cotton stalks remained on this land but no other form of organic matter was supplied. About one-fifth of the rainfall ran off. The soil losses have been at a rate sufficient to remove the topsoil to plow depth (7 inches) in 41 years.

These and other conservation station data indicate that the topsoil of class III land, practically anywhere in the Cotton Belt, in continuous row cropping and in contour culture on average slopes of terraced land will wash away to plow depth in 30 to 60 years' time. It will not go so rapidly on gentler slopes, but at a faster rate on steeper slopes.

On this typical class III land of 7-percent slope, both the water and soil losses were unevenly distributed throughout the season; they were highest in the summer and lowest in the fall. Of the average annual water loss, 30.1 percent came during the three summer months of June, July, and August, causing 50.9 percent of the year's soil loss. For the spring and summer 6-month period, March throughout August, the figures were 52.8

percent of the annual water loss and 77.2 percent of the year's soil loss.

These data serve as a very important guide in planning protective cropping methods. As elsewhere in the Cotton Belt, the runoff and erosion-control problem is many times more critical during the warm growing season, than during fall and winter. Accordingly, summer cover crops are much more needed than winter cover crops for soil-saving purposes. Experimental results show they are highly protective. Their residues are also of substantial value for soil-building purposes.

A comparison of two rotations will illustrate this point. The first is a simple 2-year cropping system, consisting of cotton, then corn, with vetch planted in cotton middles in the fall and turned under for green manure ahead of the corn. Crotalaria was broadcast in the corn to provide some additional legume cover and residue. This rotation performed satisfactorily on the class II land of 3-percent slope, reducing the water loss somewhat and the soil loss by one-third, as compared to continuous cotton. The erosion rate is not nearly as high on this class of land, as it is on class III and class IV land.

On the much more extensive class III land, represented on plots of 7-percent slope, the 5-year record, 1944-48, of this same rotation showed that the continuous cotton check plots lost an annual average of 22.2 percent runoff and 20.9 tons per acre of soil; the 2-year row crop rotation averaged 16.1 percent runoff and 7.9 tons per acre of soil. Continuous cotton yielded 805 pounds per acre of seed cotton; the cotton in rotation yielded 945 pounds per acre.

One way to judge the effectiveness of a cotton rotation for soil conservation and crop production is by means of the ratio between soil loss and cotton yield. This 2-year rotation, to date, has permitted an average loss of 44.5 pounds of soil for every pound of lint cotton produced. It is far from adequate on this class of land, principally for the reason that row cropping each year permits excessive soil loss, despite the regular use of a good winter legume cover crop, and some cornstalk and crotalaria residues.

The second rotation supplied close-growing legume-crop cover, 2 years out of 3, and also provided considerable hold-over indirect protection during the row-crop year in the form of crop residues. This 3-year rotation consisted of oats-sown lespedeza, volunteer lespedeza, and cotton. Both the oats and the lespedeza crops were harvested for grain and seed, and the combine residues left on the land.

During the 6-year period (1942-43, 1945–48) continuous cotton plots lost 23.6 percent in runoff, 26.9 tons per acre of soil and produced an average yield of 737 pounds per acre of seed cotton. The 3-year rotation averaged only 10.5-percent runoff, 3.2 tons per acre of soil loss, and produced 1,116 pounds per acre of seed cotton. Two years' growth of lespedeza preceded the cotton in rotation in 1942. The records of runoff and soil loss from cotton in the rotation were not obtained in 1944.

These results represent outstanding progress in design of a practical farm rotation that includes the production of cotton and useful grain and forage crops. During these 6 years, it reduced water loss by 55 percent, soil loss by 88 percent, and increased cotton and lespedeza yields by 51 percent. Oat yields increased from 20 to 50 bushels per acre. An average of only 15.5 pounds of soil were lost per pound of lint cotton produced in this rotation. At the indicated erosion rate of 3.24 tons of soil per acre per year, it will take 308 years to remove the topsoil to plow depth.

It is now becoming clear that real progress in conservation agriculture depends to a large extent upon how skillfully the farm operator plans, establishes, and maintains conservation cropping methods, in accordance with the specific needs and capabilities of the different classes of land on the farm.

The term, progressive conservation, used in this bulletin, refers to the maintenance feature—the progress that has been made by repeating the use of a conservation-type rotation on the same well-terraced erodible cropland year after year. For this purpose a study was made of the rotation records from the beginning in 1940, when the three crops (oats, lespedeza, and cotton) were first planted on separate experimental runoff plots, alongside the continuous cotton plot. This study terminated in 1946, when a change was made in the rotation on these particular plots.

Cotton in the rotation responded after the first lespedeza sod was turned under in 1941, with a substantial increase in the yield of seed cotton. There has been an average annual yield close to 1,000 pounds per acre, or an average increase of 368 pounds per acre for the following 6 years of the period. Continuous cotton, fertilized the same, produced only 483 pounds per acre in 1940. Its yield gradually increased to the 720 pounds per acre level in the last 2 years of the period, due to good cultural methods with recommended fertilization.

Oats produced 20 bushels per acre in the beginning, but averaged 51 bushels per acre during the final years. The use of improved oat varieties was a contributing factor. Lespedeza produced less than 1 ton of hay at the start. During the past 4 years it has averaged 1.5 tons per acre, although both the first-year and the second-year crop were harvested for seed and the combine stubble mulch was left on the land during most of the measurement period. A limited amount of analytical data[4] on changes in the content of organic matter in the soil indicates that the net increase per round of the rotation amounted to 0.23 percent, and of aggregation 8 percent.

But the most striking benefits were obtained from the constant use of this rotation. It resulted in marked savings of both soil and water. After two and one-third rounds of the rotation, the soil of the rotation plots during the cotton year had become much more absorptive, and far less erodible than the soil in the continuous cotton plot. Taking the rotation as a whole, after the initial lespedeza "build-up," the rotation has averaged only 52 percent as much water loss and 12 percent as much soil loss as from continuous cotton. This may fairly be considered a progressive record of a good rotation. It indicates what can be accomplished over a period of years by repeating the use of a good rotation on the same land.

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[4] Personal correspondence with T. C. Peele.

The final test of a conservation-type cropping practice is the erosion-production ratio. How many pounds of soil were lost for each pound of crop produced? During the last 2 years of record, 1945 and 1946, only 13.0 pounds of soil were lost from the rotation cotton plots per pound of lint cotton produced, and for the rotation as a whole, only 9.0 pounds were lost (fig. 5).

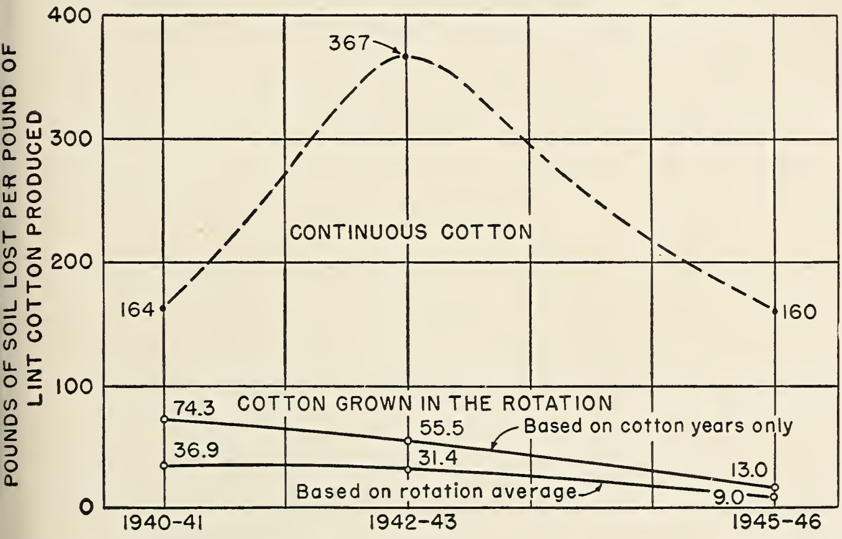

FIGURE 5.—Progressive reduction of soil losses per pound of lint cotton produced with repeated use of a conservation-type 3-year rotation on class III terraced land over a 7-year period, compared with the corresponding ratio for cotton grown continuously.

A row crop like cotton grown continuously on erodible slopes in the Cotton Belt can be expected to lose very large amounts of soil during seasons that are more than usually erosive. This happened at the Watkinsville station in 1942 and 1943. But the relative amount of soil loss from the same rains, however, remained low during the entire period of measurement when cotton was grown in the 3-year rotation. The rotation furnished effective protection under severe tests.

This rotation is a good practical one for land capable of producing, at the start, about one-half bale of cotton per acre. It is not so good on better land because heavy crops of small grain tend to choke out the lespedeza during long dry spells in the spring. It is a cropping system that will pay its way while it retards erosion and improves poor land on thousands of Piedmont farms. It is a good rotation to use until we find something better. Present prospects indicate that we may sometime be able to develop a practical rotation based on 3 or 4 years' growth of an upland grass-legume mixture, followed by a row crop and a small-grain crop. Such a rotation should furnish adequate protection to the land.

Strip Cropping

There has been considerable interest in strip cropping in the Cotton Belt, during the last 15 years.

It is a method of planting close-growing and row crops on sloping fields in alternate broad bands, or strips, on the contour. The principal purpose of this type of lay-out or placement of crops is to reduce the erosion hazard on the field as a whole.

The method is quite extensively practiced in northern sections where terraces to divert excess runoff are not so often required. The plan is most effective when close-growing crops are alternated and rotated with row-crop strips in systematic rotation order, on well-terraced land.

In the Cotton Belt, diversion terraces are generally needed on all sloping croplands. Several different patterns of strip cropping have been used on terraced cropland slopes, to support and strengthen the terracing method, and further to reduce soil and water losses as well. In practically all cases, the strip-crop patterns have also been used to serve as a means of getting good rotations under way.

The commonest pattern provides for strip cropping by terrace intervals. In this plan, one or sometimes two adjacent terrace intervals are planted to the close-growing crop of the rotation. Row-crop strips adjoin, on one or more terrace intervals, depending on the rotation used. Another, and more protective pattern, in which the crop strips "straddle the terraces," will be discussed later in some detail.

When a good strip-crop rotation has been established on a sloping field, each strip becomes a "land" in itself. Plowing, harrowing, planting, and cultivating work follows the contour. Only certain alternate strips are plowed at any one time. In the event of terrace breakage, the close-growing crop covers tend to minimize the danger of serious gullying.

These features of strip cropping have real conservation value. Another factor of major importance is the reduction of erodible slope lengths that result from the use of the strip-crop method on terraced land.

Cropping strips may be so placed that each one straddles a terrace and extends up-and-down slope to the adjacent mid-intervals. In effect, this sharply reduces the rate of erosion, as the following discussion of runoff plot results indicate:

Shortening the row-cropped slope length from 70 to 35 feet on a 7-percent slope considerably reduced soil loss on the acre basis during erosive rains. The actual volume of eroded material was reduced more than one-half. This means that a much reduced quantity of eroded soil would reach a terrace channel under field conditions when the terraces are in midstrip position. The less soil that is deposited in terrace channels, the less danger there is of terrace breakage.

Long unprotected slopes in erodible condition are dangerous. During severely erosive storms, the lower portion of the longer slopes are scoured by overwash from the upslope portion, causing higher soil loss and gullying. Pores in the soil become clogged, so that runoff is also increased. The result is that both soil and water losses are higher from long slopes. Conversely, shortening the row-crop slope length reduces these losses and the erosion hazard on the field as a whole especially during critical storms.

When a good class III land rotation like oats-lespedeza, volunteer lespedeza, and cotton is used on long, terraced slopes in the Southern Piedmont, the following "danger points" apply to different strip-crop patterns:

(1) By terrace intervals:

The strips of oats and first-year lespedeza are subject to high runoff. The volunteer lespedeza strip has relatively low runoff and allows practically no erosion. The cotton strips in rotation permit moderate runoff and erosion. There are two danger points with this pattern of strip cropping during excessive storms, especially if terrace-channel capacities are inadequate. The oats and first-year lespedeza terrace may overtop; the cotton terrace may silt-up and overtop.

(2) When strips straddle the terraces:

(a) If the strip of oats with first-year lespedeza is placed upslope and adjacent to the cotton strip, high runoff from the lower half of the strip with oats and first-year lespedeza may at times overwash the upper half of the cotton strip and cause excessive terrace-channel silting and liability to ridge breakage.

(b) *When the volunteer lespedeza strip is placed upslope and adjacent to the cotton strip, maximum protection is obtained.* During most of the excessive storms, a minimum of runoff from volunteer lespedeza flows across the cotton rows downslope. Below the cotton terrace, eroded soil washing off the lower half of the cotton strip must cross the upper half of the strip of close-growing oats with first-year lespedeza before reaching the terrace channel. These conditions favor deposition of eroded soil from the row crop in the interval rather than in the channel.

This pattern and order of cropping on the sloping terraced field supplies the best protection obtainable with this rotation. It distributes runoff more equally to the terrace channels than is possible when each cropping strip occupies an entire terrace interval. Furthermore, it has the effect of reducing the slope length of the more erodible row crop by one-half. This, in itself, eliminates substantially more than half the soil erosion from the row-crop strips, and the amount of silting in the terrace channel accordingly.

The terrace-straddling strip pattern of crop-rotation placement on sloping fields has been maintained for several years on a long sloping field of class III land on the station. Observations indicate that soil and water losses have been brought to a minimum and crop yields have been increased.

When a cropland field is newly terraced, it is frequently advisable to plant all of the crops in the rotation on the field the same year. Thus, each year's crop will be represented in turn in adjacent strips in rotation order.

There are some practical problems attendant upon this practice of straddling the terraces with the respective crops in a strip-rotation pattern. The method of laying out "lands" when turning the soil so that the terrace channel is maintained is one of these problems. Whether to provide for short rows in the row-crop space or take up all of the remaining wide spaces between the terraces with the close-growing crops is another problem. If no row-crop short rows are used in this strip-crop pattern, then small portions of the field remain in the sod crops indefinitely.

SEEDBED PREPARATION

Different methods of preparing seedbeds have received attention during recent years. The practice of ripping through lespedeza residue sods rather than turning under the sod when preparing land for cotton has been under test on the Watkinsville station for several years. Runoff plots 70 feet in length were located on Cecil sandy clay loam with a 7-percent slope. The ripped sod plots lost a little less soil and water than the turned sod plots, but the cotton yields that followed the ripping practice were sometimes considerably reduced. Other tests on replicate plots on the same class of land showed the same tendency to lower yields.

The principal difficulty was in getting a stand of cotton on land where the sod was not turned under. Ripping often caused a cloddy condition that required excessive amounts of disk harrowing. Harrowing caused the seedbed to dry out, and this, in turn, interfered with germination. Without the extra harrowing, the cloddy soil produced a poor stand. When comparable stands were occasionally obtained, there was little difference in the yield of cotton on the ripped and on the turned land.

The production of a substantial amount of close-growing legume residue material regularly in suitable rotations is of great practical importance. Heavy residues of legumes and other crops grown in rotations require good land preparation for succeeding crops. The disk implements, the disk plow, disk tiller, and disk harrow are considered the most satisfactory tools yet available for this purpose (fig. 6). In no instance has it been necessary to rake or burn off crop residues following their use. Station tests indicate that in order to prevent the formation of loose trashy dry seedbeds, it is important that stubble mulch and residue sod land be prepared a month or more in advance of planting the following spring crop. Areas with heavy residues of summer crops were prepared in late fall or winter, to provide well-settled seedbeds for spring plantings. Very little erosion occurred during the winters on the Watkinsville station runoff plots when heavy residues of lespedeza were turned under in December.

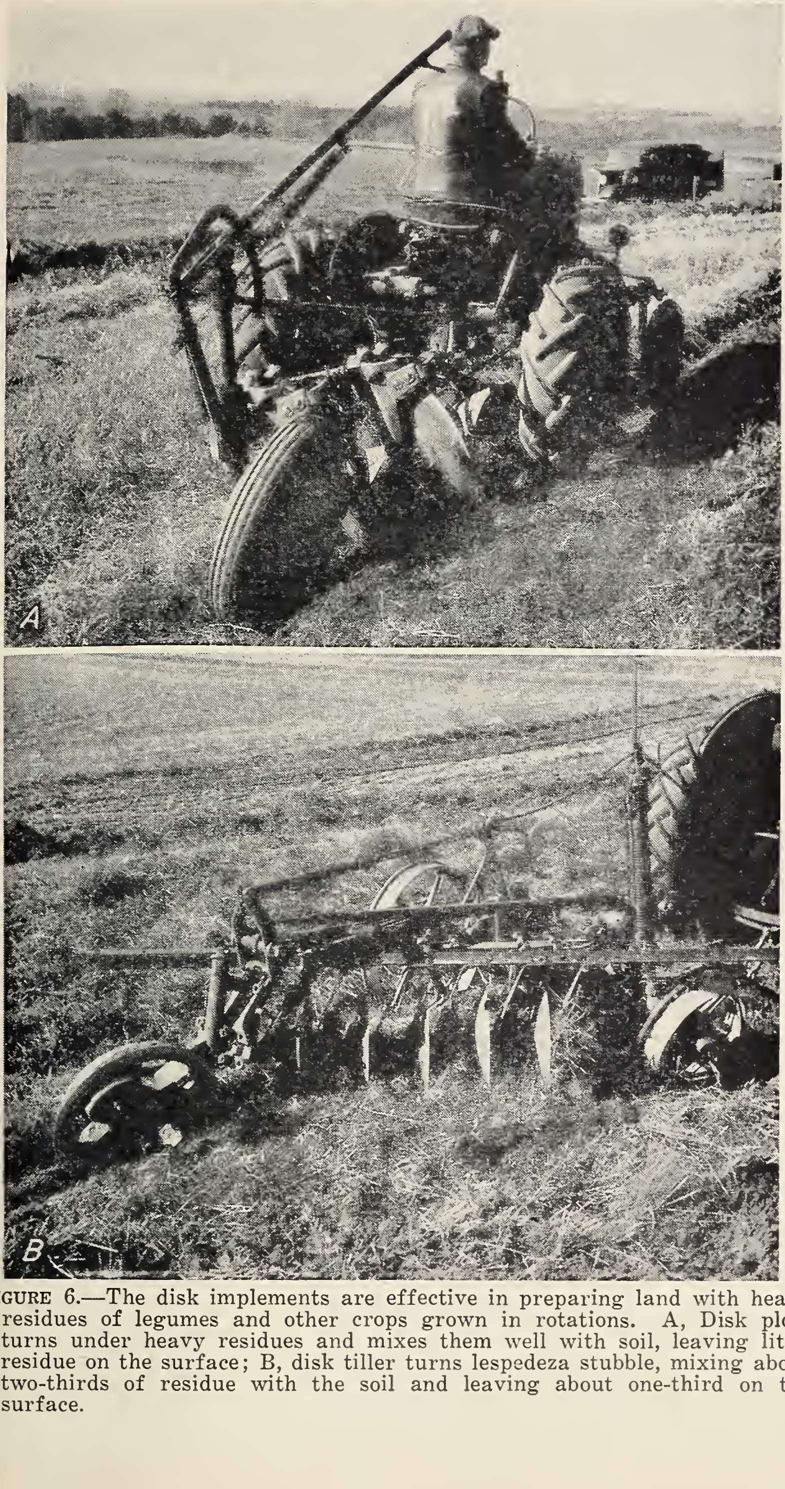

FIGURE 6.—The disk implements are effective in preparing land with heavy residues of legumes and other crops grown in rotations. A, Disk plow turns under heavy residues and mixes them well with soil, leaving little residue on the surface; B, disk tiller turns lespedeza stubble, mixing about two-thirds of residue with the soil and leaving about one-third on the surface.

The use of a newly developed straw-chopping attachment for combines should largely dispose of the trash problem. It cuts up all combine residue material as it comes out of the machine and scatters it back on the land.

Residue Tillage at the Clemson Station

Peele and others (*7*) reported results of crop-residue-tillage experiments carried on for a 4-year period, 1943-46, at the Clemson, S. C., experiment station. New types of tractor-mounted tillage tools were developed in order to prepare seedbeds in such a way that varying amounts of crop residues were left on the surface or turned under. Using vetch and rye or crimson clover as the winter crops, they secured beneficial effects in terms of reduced soil and water losses with their special methods such as "balk" and "mulch disk." Corn yields were also increased. When summer cover-crop residues of crotalaria or lespedeza were left on or near the surface in mulch-tillage methods, 2-year results showed that no yield increases occurred as compared with the usual turning under farm practice with plows. When Kobe lespedeza hay-stubble land was prepared for planting oats, the sod being turned under with plows then disked and drilled, the oats allowed considerable soil and water loss during the October-June period in two successive years. The results of disking alone were intermediate, but when a 30-inch sweep was used to loosen the seedbed the least soil and water loss resulted. The use of a sweep for subsurface tillage was, however, not considered practical.

Other Soil Conservation Research

Research in soil conservation has been in progress at various other localities in the Cotton Belt. At the Alabama Agricultural Experiment Station, Auburn, Ala., sheet-erosion studies begun in 1928 were reported in 1936 (*5*). These studies evaluated several of the principal factors involved in the erosion process. At Batesville, Ark., Starkville, Miss., and Experiment, Ga., runoff plots have been in operation for several years, but published reports are as yet unavailable.

CONSERVATION FARMING IN THE COTTON BELT

The nature of the runoff and erosion process is now much better known than it was 20 years ago. The effectiveness of such permanent covers as forest and grass has become recognized. Terracing design has been fairly well worked out. The limitations of contour culture and strip cropping as erosion-control methods are known. Some progress has been made on the major problems of conservation crop and soil management which are involved in the use of every field of sloping cropland. No satisfactory substitute has been found for the safe disposal of surplus runoff water by means of terraces and meadow outlets. These water-disposal systems, constructed according to recommendations based on research and field experience of competent agricultural engineers and soil conservationists, have received general acceptance.

Terraces need to be spaced as close together as practical for conservation purposes. Very close spacings, however, interfere with farming operations. On the other hand, very wide spacings are hazardous. For example, when the distance between terraces is doubled, the area draining into each terrace channel is also doubled and requires twice the normal channel capacity.

More serious from the conservation standpoint is the fact that increasing the erosive slope lengths increases the erosion rate in the terrace-interval areas. For excessive rainstorms, measured soil-loss data indicate that two to three times as much eroded soil will occasionally be deposited in terrace channels if normal terrace-interval slope lengths are doubled. However, since runoff and sediment may enter the terrace channel from natural drainageways this enormously increases the danger of choking channel flow of runoff water in places and is very likely to cause overtopping of the terrace ridge. When this happens on a sloping row-cropped field, the rush of water downslope across the field is very likely to break all the lower lying terraces and cause serious gullying. For this reason a poorly designed or poorly constructed and maintained terracing system is generally more of a hazard than a benefit[5].

Good use of cropland calls for a considerable change in customary farm-cropping practices, in order to provide an adequate degree of soil protection. More summer cover crops are essential. There is no other known method as effective for protection. The eroded condition of most of the sloping cropland in the Cotton Belt is a decided handicap to successful farming. Much of this land is hard, cloddy, low in plant-nutrient content and organic matter and is difficult to handle. Even though well fertilized, the added mineral nutrients are not efficiently utilized. On badly eroded land it is difficult to grow the soil-improving legume crops that are needed.

Another difficulty is that the entire Cotton Belt is subject to occasional drought periods of 2 to 4 weeks or more during the main growing season. Under the hot southern sun, many crops, such as corn, growing on eroded soils are hurt by lack of sufficient soil moisture when they need it most.

Conservation-type summer crops must necessarily be of drought-resistant, hot-weather types, tolerant of eroded soil conditions. It is for this reason that the lespedezas have proved particularly useful as summer cover. Experiments have shown that after eroded land has been conditioned by growing lespedeza for 2 or more years, it is much easier to establish stands and secure good yields of a variety of other farm crops.

Profitable farming requires good crop yields. Without exception, every conservation-type rotation under test on the Watkinsville station has increased crop yields. Direct comparisons are made of the yields of the same crop, grown on triplicate plots the same season on the same class of land with equal fertilization, in conservation rotation versus continuous cropping.

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[5] Recommended vertical terrace spacings in feet for slopes up to 10 percent may be determined by two simple formulas: Up to 6 percent: $\frac{\text{slope in percent} + 2;}{2}$ above 6 percent: $\frac{\text{slope in percent} + 6.}{3}$

But the over-all picture is clear. Erosion—past and present—has a powerful effect in decreasing the yields of common crops. Everywhere, the more eroded land failed to respond as well or as quickly to good treatment, as did the less eroded land.

Legume crop residues, as well as legume green manures, increased crop yields in all station experiments. And as the quantities of legume plant materials increased, so did the following cotton yields. Typical results are indicated in figure 7, which shows the 4-year average per-acre yields of seed cotton grown in each of five cropping systems.

The first column reading left to right of figure 7 represents the yield of cotton grown continuously without legumes.

Columns 2 and 3 represent the yields from two rotations containing one or two legumes, and a row crop each year. The cotton yields are seen to increase in proportion to the moderate quantity of legume material produced.

Column 4 shows the results from the 3-year rotation, in which lespedeza supplied ground cover for 2 years out of 3. Larger amounts of legume residue were produced, and the cotton yield increased accordingly.

The last column shows a smaller cotton-yield response to an almost equal amount of legume material, due to the fact that this 4-year rotation contained two soil-depleting summer row crops, instead of only one.

Conservation on eroding croplands generally means, first, that excess runoff water from rainstorms must be controlled so

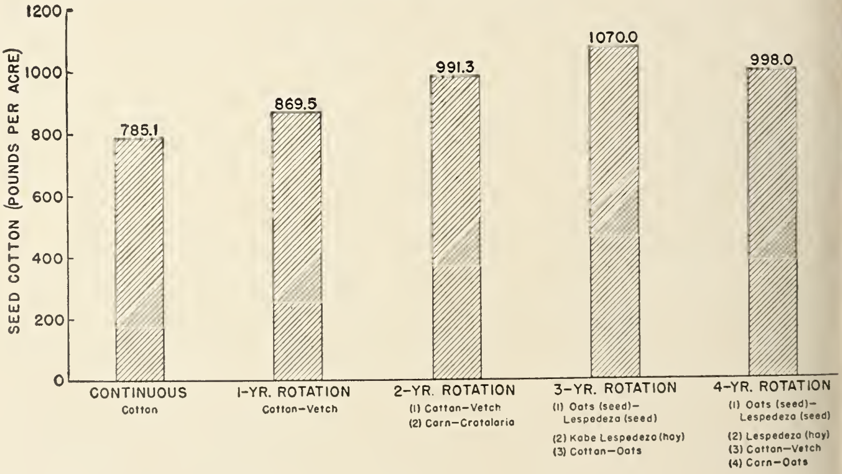

FIGURE 7.—Cotton yields from class III land planted continuously to cotton and in rotations ranging from 1 to 4 years at Southern Piedmont Conservation Experiment Station, Watkinsville, Ga. This is the 4-year average, 1944-47.

as to avoid serious gullying. On plowable croplands suitable for terracing the most satisfactory method has been to construct carefully designed water-disposal systems of meadow outlets and drainage-type terraces. This accomplished, effective use was made of soil-improving cropping methods which also reduced runoff and largely checked sheet and rill erosion between terraces.

It is important that conservation methods begin to pay off as soon as possible. A 100-acre tenant-operated experimental conservation farm unit was planned at the Watkinsville station with this need in mind.

This farm was originally a typical 100-acre cotton-corn farm containing 70 acres of cropland—some of it idle land because of past erosion on the steep slopes. The conservation farm plan map showed 20 acres best suited for kudzu and for sericea, which were planted as soon as possible. Fifty acres were terraced, and meadow outlets were constructed where necessary. A large part of the terraced cropland was seeded to small grain, in order to secure a paying winter crop and at the same time get the small grain-lespedeza rotation started. Lespedeza was seeded in the grain in early spring. Both of these crops paid good returns the first year. These close-growing crops were grown more often in the rotation on the steeper slopes than on the gently sloping fields.

Soon, higher acre yields of cotton and corn were being harvested and there was greater total production on the farm on less acres and at less cost than under the old farming system. Small grains and the lespedezas provided additional cash and feed crops, increased the farm income, reduced erosion and improved the soil.

The sericea and kudzu were fully utilized as soon as they became well established. A grass-clover pasture was improved by applying lime and fertilizer and by mowing for weed control. With the increased acreage of feed crops and pastures, it soon became practical to start building up a small dairy herd.

The last 4 years' record of business on this farm has shown that more than half of the farm income has come from livestock products. One important reason for the success of the dairy enterprise lies in the fact that no dairy feed was bought because the feed produced on the farm was enough to supply the needs. This farm has been profitable since its beginning. In recent years both the tenant's labor income and the landowner's return on investment have steadily increased.

The record of this farm has shown that most of the science and skill used in practical conservation farming is concerned with the way in which the terracing system, crop rotations, perennial cover crops, pastures, and woodlands are established and maintained on the various classes of land on the farm.

Virtually everywhere in the Cotton Belt one finds that as slopes increase, depth of topsoil decreases, indicating the effects of past erosion.

Obviously, no one crop rotation practice can be expected to fit equally well on the several different soil and slope conditions and degrees of soil deterioration represented. Rotation principles applicable to class III land have been emphasized in this publication for the reason that more cotton farmers make their living on this class of land than any other.

But practically all of the croplands in the entire Cotton Belt capable of producing at least occasional crops of cotton or other crops are subject to erosional damage and need suitable rotations. The soils are generally deficient in organic matter and plant food. The most practical and efficient way to overcome this regional characteristic is to supply necessary lime and fertilizers in rotations designed to reduce erosion, add organic matter to the soil, and at the same time provide a better variety of useful crops and products.

Perennial cover crops of kudzu and sericea are adapted to much of the steeply sloping eroded class IV land in all but the drier western portion of the Cotton Belt, on areas generally not suitable for cultivation. The acreage in these crops is increasing steadily. Various year-round crop successions for hay and grazing are being successfully developed on eroded land that was thought to be practically worthless a few years ago.

On average croplands the winter legume seed producers, including crimson clover, Caley peas, vetches, and lupines are being grown more extensively for ground cover, grazing, and green manuring. Grain sorghum of combine-harvest type is supplanting corn to some extent. The acreage in small grains, other forage crops, permanent and temporary pastures is increasing. New winter grasses in combination with annual or perennial legumes hold promise for development of practical sod-crop-based systems of crop and soil management in the future. Mechanization of the cotton crop, with flame weeders and chemical weed-control methods, and mechanical thinning and picking is making progress in the Cotton Belt at the present time. A very substantial increase in numbers of livestock on farms has occurred in the Southeast, particularly of beef and dairy cattle along with the development of improved facilities for marketing livestock and livestock products.

In recent years conservation farming has spread rapidly with the organization of soil conservation districts which now cover most of the Cotton Belt area. Cotton Belt agriculture is becoming more diversified and with increasing numbers of livestock on farms, better soil conservation is obtained as the acreage in close-growing feed crops and pasture sod crops increases. The expanding use of power machinery, particularly of combine-harvesters, has favored the production of small grain, lespedeza, and other conservation crops. These trends favor soil conservation and better land use, provided terraces are properly maintained where they are needed.

The production of cotton, however, as a well-established high-value crop can be expected to continue to occupy a prominent place in Cotton Belt agriculture. The trend is toward producing cotton in well-planned crop rotations designed to fit the particular conditions of soil type, slope, and degree of erosion (fig. 8).

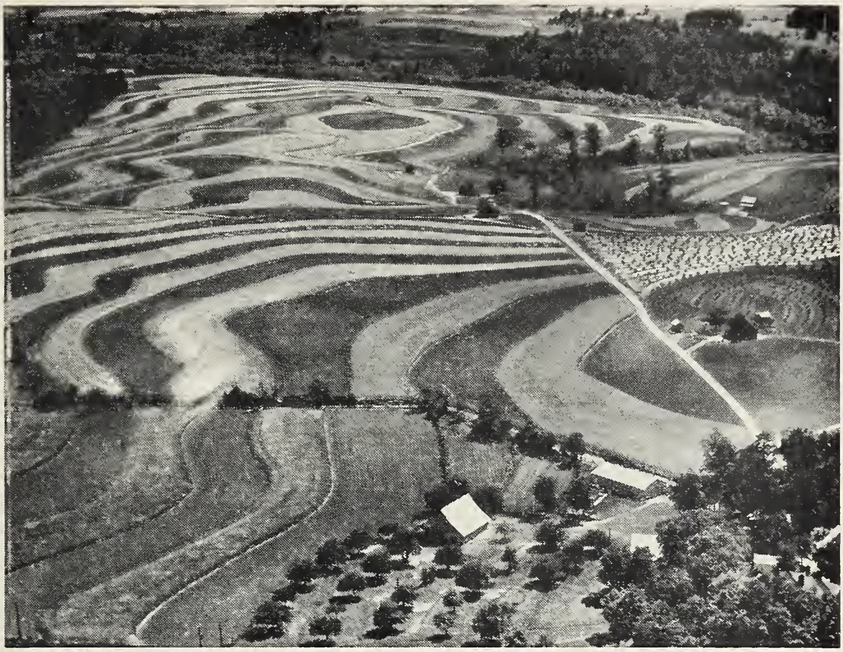

FIGURE 8.—Strip-crop rotation of cotton and small grain. The small grain is followed by annual lespedeza.

Conservation research has played an important part in supplying some of the basic information needed in farm planning. One of its most important contributions has been to point out the critical need for stronger, more protective cropping practices wherever erosion conditions are acute. Research in progress in this field is serving to evaluate the several conservation methods in use and to develop and perfect other and better methods. It is contributing much to our knowledge of the actual effectiveness, and of the limitations of individual methods once thought to be adequate. And it has proved beyond all doubt that there is no single "cure-all" soil conservation method adapted for general use in the Cotton Belt.

Research results have shown that a large total area of steeply sloping cropland in the Cotton Belt is unsuitable for row crops but can be more efficiently utilized for perennial cover crops. And, further, research shows that the land-deteriorating effects of row cropping in the past may be offset and overcome to some extent by increased use of adapted leguminous cover crops that succeed on marginal lands, when properly managed. Many of these steeper sloping fields have become so poor and so roughened by gullying that their use is limited to pasturage or reforestation. And it is this circumstance that promises to supply much of the grazing so badly needed on many Cotton Belt farms. It favors the development of a better balanced type of agriculture, including livestock enterprises.

But the research job is far from finished. It is true that runoff losses have been reduced, erosion rates slowed down, eroded soils reconditioned and improved, and crop yields increased. However, as long as rainfall that might be useful for growing crops is permitted to run off, carrying with it large quantities of soil, valuable organic matter and plant nutrients, erosion will remain as a drain on the income and resources of the farms and a continuing threat to the stability of Cotton Belt agriculture.

Research must lead the way to better cropping practices than those discussed here. Soil and water losses must be reduced to the absolute minimum. Only on such a basis can we be assured of the attainment of a permanent agriculture in the Cotton Belt.

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